Atmospheric Entry Simulation Capabilities of the IRS Plasma Wind Tunnel PWK3 for Mars and Venus

G. Herdrich*, S. Löhle and M. Marynowski

Institute of Space Systems, University of Stuttgart
e-mail: *herdrich@irs.uni-stuttgart.de*

ABSTRACT

Upon entering an atmosphere spacecrafts encounter fairly high thermo-chemical loads such that the characterization of the non-equilibrium plasma and the interaction between the plasma and the surface of thermal protection system are an important issue. Electrodeless inductively heated plasma generators enable basic thermal protection system material tests (e.g. catalysis) and the simulation of atmospheres such as of Mars or Venus. The generators have an optimized design, where the induction coil is closer to the plasma than it is with other designs. Therefore, the electromagnetic field loss is reduced. The water-cooling system surrounds both the coil and the plasma tube. The design of inductively heated plasma generator IPG4 and the associated plasma wind tunnel are described. Typical values taken reach typical Mars scenario values of 0.5 MW/m^2 and more while the total pressures are in the order of 1 kPa, that is, typical values as expected for the well-known Mars Sample Return Mission or the balloon mission of the Mars Society. A powder feeder is available to simulate the dust particles in the Martian atmosphere.

In several programs such as ESA projects within the Aurora program CO_2 conditions have been assessed and derived that are of relevance e.g. for Mars or Venus entries. On basis of heat flux and total pressure measurements local mass specific enthalpies could be determined and it could be shown that these conditions are comparable to the local mass specific enthalpies as experienced by the space craft during the atmospheric entry. These measurements were amended by optical measurements showing both the corresponding species in the plasma from both reactive processes in the working gas and interactions between the plasma and the material surface itself.

The paper is concluded with an enthalpy envelope derived from the existing data base for the inductively heated plasma wind tunnel of IRS.